Lansing (J. V.)

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BY

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Frogs, and their Contributions to Science.

The little tail-less animal we have chosen as the subject of this evening's paper, has few attractions of form, is quite retired in its habits, and stands not very high on the scale of animated beings. To most persons indeed, there is usually something forbidding in the appearance, certainly something repulsive in the touch; while the common thought thinks of frogs as it does of reptiles, such as snakes and lizards, as things to be shuddered at and avoided.

A moment's consideration, however, of the position they have occupied in the world's history, thoughts and progress compared with more pretentious animals, removes from them the idea of insignificancy, invests them with exceeding interest, and even dignifies their creation as having been designed for special, wise and holy purposes.

They figure by no means meanly in mythology, in ancient song, in sacred writ, and in later years prominently upon the page of science.

We learn from Esop, the classic and accomplished animal linguist as well as naturalist, some facts in regard to frogs in their social and individual relations, that we could not have learned in any other way. We learn that they were originally democratic in their government, and happy in their condition, but like mortals touched with feelings of vanity and ambition, they became discontented and sighed after royalty, and that Jupiter yielding to their wishes, gave them a king in the shape of a cruel stork, who, while he reigned over, amused himself by devouring

his subjects. Frogs have been essentially democratic ever since, as their free speech and seemingly equal rights in the pursuit of animal happiness testify.

Homer, the broadest winged of the Grecian poets, did not deem them unworthy of his song. The battle of the Frogs and Mice, Βατραχομυομαχια, will live as long as the story of the siege of Troy. Once are they spoken of in sacred history and though in a way not pleasant to think of, as a plague, yet as the ministers of God, to turn the heart of Pharaoh, we invest that croaking army of frogs that came up from pool, and river-side, and covered the borders of Egypt with all the awe and sanctity of a divine mission. However poorly esteemed, they can never lose the sacred character attaching to them, from this fact, that they were once selected as the special instruments of a divine purpose.

The geological record of animal forms, that lived unnumbered ages ago, unfolds here and there a fossil representative of the class we are considering. In those days of exuberant vegetable and animal life, batrachian forms of wondrous size and beauty perhaps, lived and sported, and departing left behind them foot-prints if not on the "sands of time," yet, most certainly, on the new red sandstones of Saxony and Connecticut. Admitting their antediluvian existence, it would not, from our knowledge of their natant powers, require much imagination to suppose them independent survivors of the flood, did not plutonic action and a probably high temperature of water — for the frog dies at 107° F. — forbid the idea. I have read that in a German museum there is a single specimen, that was found imbedded in amber, and that this is the only known instance of an antediluvian amphibian, that has come down to us, with its external characteristics preserved. A fitting entombment this, in fragrant

golden-colored, pellucid amber, of the only representative of his race as it lived in primitive and prenoachian times.

It is proper here that we should assign our subject its precise zoological rank and position. Until recently, following the division made by Cuvier of the vertebrate animals into four groups, viz: Mammals, Birds, Reptiles and Fishes, frogs were classed with reptiles. We are glad, as well for the name of the thing, as for its greater scientific accuracy, to have them now ranked in an order by themselves, that of amphibia, allied only to reptiles on the one hand, and fishes on the other. Strictly speaking, however, they are not capable of a double life in air and water, and therefore are not like the Banded Proteus, of pure amphibian nature. It is true, the early tadpole portion of their existence is passed in water, and respiration effected by gills; but lungs and gills are both necessary for respiring in either element. The frog dies if long enough immersed in water, and the tadpole quickly in the air.

Rana, the Latin name for frog, designates the genus under which he is classed, while under the family name of Ranidæ, resembling frogs, we find included several other genera of which the common garden and tree toads are types. But it is with the genus *Rana*, that we are concerned, or rather with the single member of that genus known as the *Rana fontinalis* or *Rana esculenta*, the common spring or green frog. In doing this we pass by the attractions of that sturdy denizen of our pools and lakes, the sonorous, rana pipiens, the bull-frog, the "bloody noun" of our school boy days, the lithsome leaping leopard frog, the *Rana palustris*, and his sober drab-coated brother, the wood-frog, the *Rana sylvatica*.

The proper study of mankind, that is, of the animal man, begins with his frame work, and after mastering this, rises to the consideration of his organic life. His habits, intellectual phenomena, and the philosophy of his being,

become thereby less difficult to understand. In a somewhat similar, and yet by no means scientific way, we propose to study frogs.

The skeleton of the frog, if placed upright, has a sufficiently human appearance to pass at first sight for that of a lilliputian child, which had been affected by some disease of the spine. There is certainly enough resemblance to permit the use in masquerade or comic woodcut of the batrachian form as the basis of caricature, a thing which cannot be done with many other animal forms.

The maxillary bones differ from each other, in that the upper alone is furnished with teeth. These are set closely together around the jaw, not springing from alveoli, but implanted on the bone. They number forty-two, with eight placed traversely on the vomer, called the palatine teeth. In taking their food, there seems nothing like mastication, the teeth serving rather as prehensile agents to prevent the escape of the struggling insect although to a certain degree the palatine teeth must triturate it, as pressed upward by the tongue it passes into the esophagus.

The cavity of the cranium is quite small, and we cannot claim for the frog from its phrenological developments, a large degree of intellectual power. It is sufficient, however, for all the practical purposes of his being. His perceptive faculties are good, as shown by his capture of insects in their rapid flight upon the wing; his judgment as to distances tolerably accurate, as shewn when disturbed on land by his reaching his haven of water by a single leap; he has a quick ear to apprehend danger, and one seemingly appreciative of his own music, and he is eminently sociable with his kind in the spring time of the year, and also during the season of hybernation.

His spinal column is made up of nine vertebræ, all of which, except the atlas, have long transverse processes, the coccyx is peculiar in its length, being almost as long

as all the vertebræ together, and reaching to the symphysis or union of the iliac bones. Ribs are wholly wanting, a fact which bears upon his method of respiration. Like man the frog rejoices in his upper and his lower extremities, particularly his lower. He has his femur, and his humerus, his radius and ulna united in a single bone, his tibia, and fibula also united, his carpal and metacarpal, tarsal, and metatarsal bones, and phalanges for his fingers and his toes.

The muscular tissue that invests the skeleton we describe, is of whitish appearance, very firm in texture and very susceptible to galvanic action. Of its delicacy as a thing of diet, or its beauty as a thing to be studied under the microscope, we will not now speak. It is with little difficulty one can pick from the thigh of the frog muscles that are analogous to those of the thigh of man. The flexors and extensors, the recti, the glutei, the gastrocnemii are all to be found well developed, and suggest from their form, origin and insertion, a series of movements similar to those made by man. Thus in swimming, man and the frog strike out peculiarly alike. It may be noticed here in regard to his aquatic feats, that he has not the power of balancing himself and moving about at different depths of the water like a fish, but is either at the surface or closely hugging the bottom, and the same is true of him to a certain degree even in the tadpole state.

A tough membranous skin invests the body, webbing the toes of the hind feet only, green and marked with dark pigment patches on the back, and tawny or golden, colored about the throat, and full of pores that serve alike as important aids in respiration and for the secretion of the slimy mucus that keeps the body cool, glistening, supple, and difficult to hold when caught by any preying enemy. The color of this tissue is not constant, but darker, greener, brighter or more leaden-hued on some

days than others, depending doubtless on the weather and the state of the circulation. Some of the Hylæ, a species of frog inhabiting trees, possess an undoubted chameleon faculty of assuming different shades of color quite perplexing to those in search of them.

The mouth of the frog is large. The tongue springing from the lower jaw is long, bifid, and when at rest turned back upon itself. A wide esophagus leads into a single stomach capable of much distension. The small intestines are slightly convoluted and terminate in a kind of pouch or cloaca, into which also empty the ureters and ovarian and seminal ducts. The anus opens on the back. The length of the alimentary canal is three or four times that of the body. In the tadpole state it is nine or ten. In man it is between five and six. The food of frogs is insects and worms which are taken on the wing or when crawling before them by a sudden darting out of the tongue and sometimes with a leap. Like the lion, styled the king of beasts, the frog preys on no dead carcass. There must be life or motion to tempt him to strike. Like man also, styled the highest animal, he sometimes preys upon his own species. In a jar, in which I once kept some frogs, there was a rare specimen of a Hyla, a dimunitive kind of tree frog which I one day missed. Noticing an undue fullness of the stomach of one of his larger companions I performed upon him the operation of gastrotomy and delivered my Hyla, like a second Jonah, a little the worse for the gastric juice of his devourer but still living.

The lymphatic and lacteal system of the frog is highly developed. A pair of pulsating lymphatic hearts may be easily detected, one on each side of the coccyx, while another pair is found not so easily, under the posterior edge of the scapulæ. Their nervous system is also exceedingly well developed. The peculiarity attending the

course of the femoral nerve, made up as it is on each side by four filaments given off from the spinal cord at the last four vertebræ, and passing down on the outside of the ilia, permit its easy isolation, and the making of it for purposes of experimental inquiry, the sole channel of communication between the lower extremities and the trunk. The nerves of special sense, those of sight, hearing, taste, and smell, are easily traced. Sensation is more perfect about the head than the body. The eye is comparatively large, prominent and lustrous, and is beautiful to look at, or study. Its iris is not dilatable, so far as I can perceive. Besides two palpabræ, it is guarded by a semi-transparent membrana nictitans. The ear has no external orifice. A scale like membrane covers the auditory canal, like a drum-head, and communicates its vibrations to the nerve. The sense of sight is keen, that of hearing good, while those of taste and smell, from anatomical reasons, are not deemed sources of very exquisite enjoyment.

In the early tadpole portion of his life, the frog respires like a fish, by the aid of branchiæ or gills, but in the progress of his development, these, with the single heart connected with them, give place to the true lungs and the true heart, having a ventricle and two auricles. From the manner in which the circulation is thereby effected, the venous and arterial currents being mingled, aeration of the blood is but imperfectly accomplished. The frog breathes through his nose, never by his mouth. The air is drawn in by the expansion of the muscles of the throat and forced by their contraction, the nostrils being plugged as it were by the tongue on the inside, into the lungs. Expiration is effected by the muscles of the abdomen. The want of ribs in the formation of the thoracic cavity make this process of swallowing the air a necessity. The number of respirations is about eighty per minute, the aeration of the blood being as already stated greatly aided

by means of the skin. He would die as certainly if his skin were covered by viscid oil or varnish, as if his mouth were held open, and in either case it would be death by suffocation.

Behind the ear of the male frog, for they alone are provided with the apparatus, there is a membranous sac into which the air is forced as into a bladder by the action of the muscles of the throat and abdomen. On its passage inwards, not outwards over the tongue, it gives rise to the peculiar croak, or *croassement*, as the French have it, of the frog. Aristophanes, in one of his comedies, speaks of frogs as the song living race, the marshy offspring of the fountains, and tried to express the chanting of their varied watery choral music amid the noise of bursting bubbles, by the Greek words Βρεκεκεκὲξ κοὰξ κοὰξ. There are three different sounds emitted by the frog, as I have noticed them, a kind of wooing, muttering on the part of the male in the spring, the regular orthodox croak, and a cry of agony or pain which I have heard him utter while being swallowed by the snake. There is a popular misapprehension in regard to these sounds, I think, which confounds the long monotonous roll of the toad, and the sharp cry of the newt, with those of the frog. It is, by no means an unpleasant thing, however, of a warm spring evening to listen to the lively music of a densely populated frog swamp. The continuous clatter of a thousand croaking throats rising and falling in intensity, accompanied perhaps by the deep bass of some lonely rana pipiens, or the plaintive cadence of the sluggish toad, or the shrill piping of the little water newt, make up, if listened to aright, a veritable concord of sweet sounds.

The first notes of the frog in spring are pleasant, through association. Like those of the robin or blue bird they are listened to as the harbingers of sunny days, and budding flowers, and a new life. It is a common saying

with farmers that after their first appearance they must be three times driven to their marshy beds by frost and ice before the reign of winter ceases and that of gentle spring begins.

With the first warm days of spring, however, in this latitude about the last of March, an upward impulse seems to bring him from "the depths where he did lie" and as the temperature of the water rises towards 60° his activity and clamor increase. The blood, long stagnant, courses with renewed activity, and desires, dormant for a twelve month, awake to a new life. The little membranous sacs we have spoken of vibrate unceasingly, pealing forth what has been called "the tocsin of copulation." A Frenchman once wrote and published a Memoir on *Les Amours des Sauriens*. A Frenchman alone is qualified to describe the loves of the frogs.

The male has no intromittent organ, and therefore impregnation occurs without actual coitus. Establishing himself on the back of the female with his arms clasped firmly in a kind of tonic spasm about her body below the scapulæ, he resigns himself for a period of from fifteen to thirty days to a seemingly passive enjoyment of his position. The impregnation of the ova takes place after they have left the female. In their passage forth they are enveloped in a gelatinous covering, which absorbing water makes an aggregate floating jelly-like mass many times the size of the body from which it emanates. It is commonly known by the name of frog spawn. Each female lays from six to twelve hundred eggs, lays them but once a year, and does not reproduce them after the third or fourth year.

The natural age to which the frog attains is not well determined. It probably reaches from six to nine years. The rana pipiens certainly lives much longer. Some specimens that I have seen had all the marks of being

ancient patriarchs. An old farmer told me that he had distinctly recognized, for over twenty years, the peculiar form and tone of one of these burly lords of the pool.

The tadpole is developed from the egg in from seven to ten days according to the warmth of the air and water. It is instructive to watch from day to day the progress of this embryonic life, and amusing at the last to see some precocious member bursting his cell wall and come wiggling forth rejoicing as a polliwog. The life of the tadpole is in all respects like the life of a fish. It breathes by gills, and feeds on minute animalculæ and vegetable growths. By aid of these, and warmth, and sunlight; and by the law of his being he approaches in from seven to ten weeks the limit of his aquatic life. Little papillæ appear on each side at the back of the neck where legs, the hind legs, of the future frog are soon to burst through. The tail grows shorter and stumpier, and he rises oftener to the surface to breathe in and out a bubble of air as if to test the veritable lungs that are to replace his primitive gills. At length the jaws, already apparent through the skin, have separated, and the mouth becomes an open fact, and then the upper legs or arms follow in the footsteps of the lower. Little by little the tail has kept decreasing, not dropping off suddenly, but absorbed atom by atom by the action of the capillary blood vessels, until at last it serves no longer as a source of locomotive pride. The change is now complete, and the young frog, a tadpole no longer, enters in a new element upon another and higher stage of existence. There is something wonderfully interesting in this change from an inferior to a superior life. Bishop Butler's analogical argument to prove the immortality of the soul drawn from the worm, the chrysalis, and the butterfly, might be strengthened here, if need be by another and no less striking illustration. Less grave, also, are the social analogies it presents of human polliwogs, whole families of them,

who may be seen wiggling along through life in the tadpole state, and whose transition to a higher grade of social being, although earnestly striven for, cannot possibly be accomplished under one or two generations.

Having spoken of frogs anatomically, physiologically, and in a measure, æsthetically, it remains for us to speak of them historically in connection with important discoveries in science to which they have contributed.

In 1770, at Bologna, Italy, in his own domestic laboratory, a tall, thoughtful-browed professor was busy testing and watching the manifestations of that mysterious agent, electricity, to the study of which the learned men of Europe, incited by the discoveries of our own Franklin, were just then giving especial attention. Perhaps to cheer his weary brain, perhaps to worry him with some trifling household topic, his wife bearing in her hand a plateful of dressed frogs' legs tarries on her way to the kitchen. The professor stops the turning of his cumbersome machine to listen, the wife sets down her plate to talk. It might have happened in a dozen ways, but the startling fact was then first remarked, that contact with the metallic conducting rod threw the frogs' legs into violent convulsions. Although as yet uncooked, they were food indeed for the professor. The germ of discovery had here its inception, and began its growth in his mind. From that day the laboratory consumed more frogs than the kitchen. After a year's patient experimenting, there was announced to the scientific world in 1791, the remarkable discovery of the electrical effect produced by the contact of animal parts with metallic substances, in a publication entitled, *Aloysii Galvani, de Viribus Electricitatis in Motu Musculari, Commentarius.*

Since that time the earth has been girdled with the name and the fame of Galvani. His discovery was the starting point for numberless experiments on frogs and metals,

until Volta, in 1800, extended it to the production of electrical effects by contact of different metals, and conceived the grand idea of what is known as Volta's pile. From this, progress in the knowledge and applications of electricity was wonderfully increased, until now we cannot estimate its influence. In chemistry, in the arts, in the spread of printed leaves, and in the transmission of thought regardless of intervening space, it has become the great agent of the world's civilization. In this very building, where this last and crowning application of the electric current to telegraphic purposes was first conceived and actually put in practice, is it not meet that we should link the glory of the achievement with the memory of the martyred frogs that gave the primitive idea birth? Could they speak from beneath the scientific altars upon which they were so freely sacrificed, might not each one exultingly croak at the recital of the fact we have stated

Quorum pars minima fui?

It is, however, in the great field of physiological researches, and in the solution of questions relative to man's organic being, that we find the frog most intimately and happily associated.

Probably one of the most important discoveries in physiology of the present century is that of Marshall Hall published in 1826, of the true spinal, or, as now called diastaltic system, or system of reflex action. It is that system of incident and reflex nerves connected with the spinal axis as a centre, and which presides over all the functions of the body, and on which depends the preservation of the individual and the continuance of the species. We breathe, we swallow, we wink the eye, we sneeze, we vomit, we excrete, emit, extrude, and do a hundred things beside by virtue of the operation of this law. It is a kind of motion or action, the first to be exhibited in the

fœtus, and the last to disappear upon death. Each function we have mentioned has its diastaltic arc as it is called, that is, a nerve furnishing the way of communication from the surface to the centre, which would be the cord and its extension the medulla oblongata and a nerve from the centre communicating to the surface. For instance, the presence of carbonic acid in the capillaries of the lung stimulates the fibres of the pneumogastric nerve, and gently says, I want more oxygen. The message travels to the centre, and the response comes back along different nerves to the muscles of the back, the intercostal muscles and the diaphragm. The cavity of the thorax widens and air rushes in. Now it is only by knowledge of the true physiology of functions that we can rightly or rationally proceed to restore them if disordered. It becomes, therefore, a practical and all important matter in the treatment of disease to know just how far we are permitted to lift the veil that hides its true locality and nature, as well as to know the true and proper direction in which to bend our efforts and address our remedies. Since the promulgation of Marshall Hall's discovery, the diagnosis of diseases has been greatly sharpened, and the practice of medicine simplified and rationalized. The law of diastaltic action is to the medical world what gravity is to the physical. If we have spoken of it at tedious length, its importance and the application we wish to make of it must be our excuse. That application is simply this: that the discovery was suggested to Dr. Hall's mind by witnessing the automatic motions of decapitated frogs and newts, and elucidated by a systematic series of experiments upon these and other animals, but especially upon frogs, by reason of the facility with which they could be procured, and the peculiar susceptibility of their nervous system.

We do not claim for frogs, that they were the instruments ushering in Harvey's great discovery of the circula-

tion of the blood, but we do say that they furnished the last fact required for the full and perfect proof of the doctrine he maintained. The actual transition of the blood from the arteries to the veins was first observed by Malpighi in the large capillaries of the web of the frog's foot.

To sit in some window above a crowded street and watch the different currents of thronging humanity beneath, is attractive to most minds, merely as an exhibition of moving life. So to sit above the little world, the microscope discloses in the transparent tissues of the frog, and watch the moving blood currents through the capillaries, even to unprofessional eyes, is strangely interesting. Now the quick throbbing arterial wave, now the sluggish venous flow, catches the eye. Now the tumbling procession of globules crowd through some larger capillary, now each individual globule glides along some narrow passage way, in single file. Now the crimson tide stops a moment, recedes, goes on, stops again like the heart beat, watched by Uncle Toby. Altogether, the spectacle is one seldom tiresome to the beholder.

Our knowledge of almost all the important facts in physiology connected with the circulation, has been obtained by the study of its phenomena as exhibited in the frog. Thus, for instance, that the capillary circulation is not controlled by the heart's action, but depends on the nutritive, and other chemical changes which the blood undergoes in its passage along the walls of the minute capillaries. Thus also was established the existence of the white corpuscles of the blood, as well as the red, and their peculiar route of travel. Indeed, in no class of animals can the corpuscular changes of the blood be better, or more readily studied, than in the frog. Again in the true appreciation of that condition of the circulation, known as congestion, and its distinction from the process called inflammation, about which as many vague things have

been written, and as many crude ideas held as any other in medicine, we are able to eliminate much of the confusion that has so long attended these terms, and prevent the mistakes by no means uncommon in the treatment of disease occasioned by this very confusion.

But we have said enough, perhaps, of these medical associations of our subject, for while there is much material remaining, showing how intimately connected have been the lives and deaths of frogs and the progress of physiological science, it would doubtless have more of professional than general interest. We pass by therefore, the many questions making up the mystery of our being, which they have helped to elucidate or solve; questions, about the workings of the nervous system, about rudimentary or embryonic life, changes of form, transitions from inferior to superior organizations, and finally questions in medical jurisprudence, even, where they have lent their mute though striking testimony in the detection of hidden crime.

If, what we have said, removes from any mind the idea of their insignificancy, or redeems them from the reproachful utilitarian inquiry sometimes made of animals lower than ourselves, of wherefore were they made, it will have answered our purpose.

In conclusion, we are, for ourselves, free to confess that we love the frogs. We love them as table delicacies, for the music they make, and for the good they have been to man. We never pass them by, when their full chorus is ringing upon the night air, with its deep bass, and airy alto mingling harmoniously, without a thrill of pleasure intensified by the recollection of their history and associations. Individually they are full of interest. They have a certain grace of form and motion, a certain beauty of color, a bright eye, and a tongue not devoid of melody. As a class they deserve respectful recognition by virtue of

the uncomplaining and unnumbered sacrifices made of them upon the shrine of science. Yes! let us all love the frogs; we will be better physiologists for it, and I doubt not, more devoutly minded. For, as Coleridge says,

> He prayeth best, who loveth best,
> All things, both great and small.
> For the dear God, who loveth us,
> He made, and loveth all.

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